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PRINTING AND CHECKING FOR LINEAR PROGRAMMING CODES*

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P-925 $H

August 23, 1956

*Prepared for The RAND Corporation Short Course in Computational Aspects of Linear Programming, September 4–13, 1956.

The RAND Corporation
1700 MAIN ST. • SANTA MONICA • CALIFORNIA

PRINTING AND CHECKING FOR LINEAR PROGRAMMING CODES

H. A. Judd

The print subroutine in the LP code is quite dependent on the master code both for instruction and for data. It is never called into high speed storage unless the data is ripe for printing. It does not have to know whether the printed output will prove a good or bad omen for the operator.

An individual print-out consists of m + 4 lines of information. The first line is the problem identification that the operator assembled when the data was loaded originally. The second line specifies the current iteration number, the stage number, the form number (i.e., the row index of the current objective form being optimized) and the caption describing the type of print-out. There are 14 different captions, each of which is intended to be descriptive of the reason for printing. On five of the print-outs, the program prints S IS XXXXX on the second line so the operator will know that the activity XXXXX came into the basis on the completed iteration or cycle.

The third line is a set of headings which identify the different columns of printing on succeeding lines. The first column is labeled J and denotes the activity names for those columns which are currently in the basis. The second column is called BETA, indicating the current solution. The third column is I for the row index i which runs from 0 to m. The

fourth column is variable, depending on the type of print-out. It may be headed by one of the following:

B for b^i (or $b^{i(T)}$ in PLP)

E for $\eta_r^{i(T)}$

G for $\gamma^{i(T-1)}$

A for $\alpha^i_{s(T)}$.

The fifth may be

ER for ϵ^i (error)

PI for $\pi_i^{(T)}$

or, for one type of print-out, blank.

The fourteen captions with the corresponding heads for the fourth and fifth columns are:

CYCLE PRINT	S IS XXXXX	E	PI
NEW SOLUTION	S IS XXXXX	B	PI
CHECK SOLUTION		B	ER
END OF PHASE ONE		B	ER
END OF STAGE		B	ER
NO FEASIBLE SOLUTION		B	ER
FEASIBLE SOLUTION		B	ER
OPTIMAL SOLUTION		B	ER
PRIMAL-DUAL SOLUTIONS		B	PI
UNBOUNDED SOLUTION	S IS XXXXX	A	PI
RIGHT HAND SIDE OPEN	S IS XXXXX	G	PI

MATRIX SINGULAR	S IS XXXXX	A	
BASIS INVERTED		B	ER
THETA AT MAXIMUM		B	ER

Before describing each of these types of print-outs, it seems necessary to point out that on-line printing is not the only conceivable way of getting information out of the machine. Printing is very time consuming or, stated in simpler economic terms, expensive, as compared with computing time. If too much information is printed, it becomes very repetitious and boring. If too little is printed, a part of the problem solution may be lost which is of definite interest. In order to satisfy the general need, this program offers a choice of how much should be output. Sense switches are used to control on-line or off-line printing.

In general, sense switch 3 instructs the program to write the information on tape 6 for off-line printing. If a more permanent record of this information is desired, this tape can be used to punch cards on the off-line punch. A card would be produced corresponding to each line of printed information, so these cards could be read and printed by an IBM type 407 accounting machine.

If a snapshot of the current solution at each iteration is desired, it is necessary to use sense switch 5 in combination with sense switch 3 or 4 or both. Switch 5 would instruct the program to print a CYCLE PRINT and switch 3 instructs the program to print off-line while switch 4 directs the program to print on-line. In addition to the current solution,

β_1, the transformation vector E, and the current pricing vector, $\pi_1^{(T)}$, are printed. Much of this information is retained internally in floating point form, but the print program converts it to fixed point form before printing. For each number it prints eight digits of integer, a decimal point, eight digits of the fraction and the sign. Leading zeros and positive signs are not printed.

During PLP operation a print-out captioned NEW SOLUTION will occur every iteration if $\theta_r \neq 0$ and switch 3 or 4 is down. Since θ_r will be non-zero on nearly every iteration, on-line printing would slow up the PLP operation considerably. Hence, the additional sense switch control is used to allow the operator to peek at the current solution and then turn it off. It is possible with this arrangement to put all of this information on tape while he slows up the operation just once in a while by printing the information on-line.

If the operator is truly suspicious that an error has occurred, he may allay his suspicions by pressing sense switch 6 down. This causes the code to check its current solution at the end of the iteration. The MCR will then scan the errors, and if it finds one greater than 2^{-26}, it will print a CHECK SOLUTION and stop. If no errors are found which exceed 2^{-26}, it will stop to indicate the check has been performed and allow the operator to return switch 6 to its normal position before proceeding. The iteration number and stage number are displayed on the console.

Upon completion of a phase I, the code will automatically check the solution, print with a caption END OF PHASE ONE on-line (also off-line if switch 3 is down) and punch end-of-stage punch-outs. If an error greater than 2^{-26} occurs or if sense switch 1 is down, the code will stop. If no error is as large as 2^{-26} and switch 1 is up, the code will proceed to the next phase without pause.

When the code completes a stage, it checks the solution. Printing occurs only if there is an error or sense switch 1 is down. If sense switch 3 is down, there will be off-line printing too. Restart information is always punched. After the punch-out there will be a program stop if the on-line print occurred. Sense switch 1 is used to interrupt operations so the operator can take the problem off the machine.

The OPTIMAL SOLUTION print-out followed by a PRIMAL-DUAL SOLUTIONS print-out will always be printed on-line (and off-line if switch 3 is down) whenever an optimal solution is attained. After the second print-out, the computer will stop. If it has optimized the last objective form, all four sense lights will be lit when the computer stops, and pressing the "start" button will have no effect. If the objective form that was optimized was not the last, the lights will not be turned on, and pressing the "start" button will cause the code to proceed to optimize the next objective form.

The THETA AT MAXIMUM print-out terminates PLP operations in the same way that the OPTIMAL SOLUTION print-out terminates the COMPOSITE operation. The code does not stop until after the PRIMAL-DUAL SOLUTIONS are printed. All of the other

print-outs occur on-line (and off-line if switch 3 is down) whenever they are applicable. They may be construed as fully annotated remarks to the operator.

There is another printing program which did not fit in the above scheme. It is the DELTA J MCR which can be used at any time to print J and DELTA J, 3 per line, for all activities. It is most convenient and informative to use at the conclusion of a problem. No distinction is made between activities which are in or out of the basis.

There are only two possible sources of errors which can be detected by the LP code. There are errors because the 704 has malfunctioned, or there are errors associated with the problem formulation. Errors of the first type should include those attributed to the LP code and operating errors. The program steps are checked as they are entered into the 704. No further checking on the storage of the code is done since failures on the 704 are usually drastic failures or none at all. The tape units have checking features in the hardware, so the LP code depends on these checks.

If an error is detected while reading a tape, the code will automatically space the tape backward and try to read the information correctly before it uses the data. In fact, there may be repeated errors on the same set of data so the code will try rereading five times before it stops. When it stops, the operator may try reading the information again

as many times as he presses the "start" button. If this also fails, it may be necessary to look at the address portion of the lights indicating the storage register on the 704 console. The octal address shown there will be found in the list of error stops so the operator can determine which tape is causing trouble and then decide what to do.

All of the stops in the LP code are effected by using the Halt and Proceed instruction so the address part can be used for easy reference to the list of stops. If the stop is of a type such that it is nonsensical to proceed, the next sequential instruction will be an unconditional transfer of control back to the Halt and Proceed instruction again. Thus, the operator cannot make an error by pressing the "start" button when the 704 stops.

Opposite each listed stop is a short explanation of why the program stopped and in which MCR or subroutine the difficulty was detected. If it is possible that the computer failed during the current iteration, one can press the "reset" and "load drum" buttons on the console to repeat the current iteration. At the end of each iteration, the new solution, basis headings, and constants are stored on the drum just for these emergencies. If repeating the iteration fails, it is then necessary to back up to the last end-of-stage punch-outs. The problem may be restarted from the stopping point by inverting the basis and then proceeding with the current MCR.

Experience has shown that many of the errors can be traced to wrong data or, more generally, to the problem formulation. This should include the errors encountered by assembling the problem incorrectly, key punching errors, or even more fundamental mathematical errors. These difficulties may become evident when the 704 starts to print with one of the following captions:

MATRIX SINGULAR

NO FEASIBLE SOLUTION

RIGHT HAND SIDE OPEN

or

UNBOUNDED SOLUTION.

Checking, like printing, is at best a compromise since it requires time-consuming operations to achieve complete checking. The LP code has been designed to perform an efficient operation with a modicum of checks and a maximum of honest-to-goodness computing.

APPENDIX

A sample problem is given on the following pages. It is a fourteen-equation problem which was set up for phase 1 operation. The phase 1 was actually trivial, as the code discovered before the first iteration was computed. After the OPTIMAL SOLUTION a parametric programming run was done with b^5 as the element being reduced. All of the parametric run for which $\theta_r \neq 0$ was printed. In addition, samples of other print captions are given. One shows a list of errors in the ER column.

CARD COLUMNS ILLUSTRATING INPUT

```
         1111111111222222222233333333334444444444
1234567890123456789012345678901234567890123456789
 - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

9 99
 ULLMANS ILLUSTRATIVE LP MODEL OF OIL REFINERY SCHEDULING
14         1          2          1
2   UP002 3   UP003 4   UP004 5   UP005 9   UP009
FIRST B
      2   9500
      3   8500
      4   8000
      5   14000
      9   3500
NEXT B
      5  -1000
MATRIX
 UP0022    1
 UP0033    1
 UP0044    1
 CRUD10    1 8
 CRUD12    1
 CRUD15    1
 CRUD16   - 55
 CRUD17   - 2
 CRUD18   - 1
 CRUD110  - 04
 CRUD111  - 04
 CRUD112  - 03
 CRUD113  - 02
 CRUD114  - 02
 CRUD20    1 9
 CRUD23    1
 CRUD25    1
 CRUD27   - 12
 CRUD26   - 61
 CRUD28   - 07
 CRUD210  - 06
 CRUD211  - 05
 CRUD212  - 04
 CRUD213  - 02
 CRUD214  - 03
 CRUD30    2
 CRUD34    1
 CRUD35    1
 CRUD36   - 5
 CRUD37   - 11
 CRUD38   - 14
 CRUD310  - 05
 CRUD311  - 08
 CRUD312  - 05
 CRUD313  - 03
 CRUD314  - 04
```

```
           11111111112222222222333333333344444444444
  123456789012345678901234567890123456789012345678 9
  - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

   UP0055    1
   CRACF0      16
   CRACF6    1
   CRACF8   - 6
   CRACF9    1
   CRACF10 - 06
   CRACF11 - 04
   CRACF12 - 04
   CRACF13 - 06
   CRACF14 - 12
   CRACD0      21
   CRACD7    1
   CRACD8   - 2
   CRACD9    1
   CRACD10 - 41
   CRACD11 - 2
   CRACD12 - 04
   CRACD13 - 12
   CRACD14 - 16
   CRACS0      21
   CRACS8    1
   CRACS9    1
   CRACS10 - 3
   CRACS11 - 3
   CRACS12 - 04
   CRACS13 - 1
   CRACS14 - 14
   UP0099    1
   FUEL  0   -1  8
   FUEL  6    1
   DIESL0   -4
   DIESL7    1
   STOVE0   -4  2
   STOVE8    1
   GAS   0   -5  5
   GAS   10     2
   GAS   11     3
   GAS   12     25
   GAS   13     1
   GAS   14     15
   COMPD0   -4
   COMPD10   1
   COMPC0   -4  1
   COMPC11   1
   COMPB0   -4  2
   COMPB12   1
   COMPA0   -4  3
   COMPA13   1
   CASIN0   -3  3
   CASIN14   1
  EOF
```

ULLMANS ILLUSTRATIVE LP MODEL OF OIL REFINERY SCHEDULING

ITERATION STAGE 00 FORM 00 END OF PHASE ONE

J	BETA	I	B	ER	
	.		.	.	-
	.	1	.	.	-
UP002	9500.00000000	2	9500.00000000	.	-
UP003	8500.00000000	3	8500.00000000	.	-
UP004	8000.00000000	4	8000.00000000	.	-
UP005	14000.00000000	5	14000.00000000	.	-
	.	6	.	.	-
	.	7	.	.	-
	.	8	.	.	-
UP009	3500.00000000	9	3500.00000000	.	-
	.	10	.	.	-
	.	11	.	.	-
	.	12	.	.	-
	.	13	.	.	-
	.	14	.	.	-

ULLMANS ILLUSTRATIVE LP MODEL OF OIL REFINERY SCHEDULING

ITERATION 17 STAGE 00 FORM 00 OPTIMAL SOLUTION

J	BETA	I	B	ER	
	24044.56915692		.	.	
	. -	1	.	.	
COMPC	155.99998855	2	9500.00000000	.	-
UP003	8500.00000000	3	8500.00000000	.	-
UP002	3499.99999999	4	8000.00000000	.	-
CRUD3	7999.99999999	5	14000.00000000	.	
CRACF	3500.00000000	6	.	.	-
FUEL	3799.99971389	7	.	.	-
STOVE	3819.99802589	8	.	.	-
DIESL	2079.99801635	9	3500.00000000	.	-
COMPD	274.00028800	10	.	.	-
GAS	2879.99725341	11	.	.	-
CRUD1	6000.00000000	12	.	.	-
COMPA	282.00000572	13	.	.	-
CASIN	428.00000381	14	.	.	-

ULLMANS ILLUSTRATIVE LP MODEL OF OIL REFINERY SCHEDULING

ITERATION 17 STAGE 01 FORM 00 PRIMAL-DUAL SOLUTIONS

J	BETA	I	B	PI
	24044.56915692		.	1.00000000
	. -	1	.	.
COMPC	155.99998855	2	9500.00000000	.
UP003	8500.00000000	3	8500.00000000	.
UP002	3499.99999999	4	8000.00000000	.03459986
CRUD3	7999.99999999	5	14000.00000000	1.19139822
CRACF	3500.00000000	6	.	1.79999995
FUEL	3799.99971389	7	.	4.00000000
STOVE	3819.99802589	8	.	4.19999980
DIESL	2079.99801635	9	3500.00000000	2.02519857
COMPD	274.00028800	10	.	4.00000000
GAS	2879.99725341	11	.	4.09999990
CRUD1	6000.00000000	12	.	10.18000752
COMPA	282.00000572	13	.	4.29999995
CASIN	428.00000381	14	.	3.29999995

ULLMANS ILLUSTRATIVE LP MODEL OF OIL REFINERY SCHEDULING

ITERATION 17 STAGE 01 FORM 00 S IS 00000 NEW SOLUTION

J	BETA	I	B	PI
	16896.17978963		.	1.00000000
	. -	1	.	.
COMPC	131.99997711	2	9500.00000000	.
UP003	8500.00000000	3	8500.00000000	.
UP002	9499.99999999	4	8000.00000000	.03459986
CRUD3	7999.99999999	5	7999.99999999	1.19139822
CRACF	3499.99999999	6	.	1.79999995
FUEL	499.99999999	7	.	4.00000000
STOVE	3219.99859809	8	.	4.19999980
DIESL	879.99916076	9	3500.00000000	2.02519857
COMPD	178.00024223	10	.	4.00000000
GAS	2159.99794006	11	.	4.09999990
CRUD1	.	12	.	10.18000752
COMPA	233.99998283	13	.	4.29999995
CASIN	415.99991226	14	.	3.29999995

ULLMANS ILLUSTRATIVE LP MODEL OF OIL REFINERY SCHEDULING

ITERATION 18 STAGE 01 FORM 00 S IS UP004 NEW SOLUTION

J	BETA	I	B	PI
	15670.18169316		.	1.00000000
	. -	1	.	.
COMPC	111.99998664	2	9500.00000000	.
UP003	8500.00000000	3	8500.00000000	.
UP002	9499.99999999	4	8000.00000000	.03459986
CRUD3	7000.00000000	5	7000.00000000	1.19139822
CRACF	3499.99999999	6	.	1.79999995
FUEL	.	7	.	4.00000000
STOVE	3079.99873161	8	.	4.19999980
DIESL	769.99926567	9	3500.00000000	2.02519857
COMPD	168.00021362	10	.	4.00000000
GAS	1959.99813079	11	.	4.09999990
UP004	999.99999999	12	.	10.18000752
COMPA	223.99997329	13	.	4.29999995
CASIN	405.99989318	14	.	3.29999995

ULLMANS ILLUSTRATIVE LP MODEL OF OIL REFINERY SCHEDULING

ITERATION 19 STAGE 01 FORM 00 S IS CRUD1 NEW SOLUTION

J	BETA	I	B	PI
	14692.05042871		.	1.00000000
	. -	1	.	.
COMPC	.	2	9500.00000000	.
UP003	8500.00000000	3	8500.00000000	.
UP002	3277.77357454	4	8000.00000000	.
CRUD3	155.55152539	5	6377.77795085	1.22599809
CRACF	3500.00000000	6	.	1.79999995
CRUD1	6222.22642545	7	.	4.00000000
STOVE	2743.99890814	8	.	4.19999980
DIESL	1261.55474977	9	3500.00000000	2.02519857
COMPD	199.11120333	10	.	4.00000000
GAS	1337.77620033	11	.	4.09999990
UP004	7844.44847460	12	.	10.18000752
COMPA	205.33325841	13	.	4.29999995
CASIN	349.99982568	14	.	3.29999995

ULLMANS ILLUSTRATIVE LP MODEL OF OIL REFINERY SCHEDULING

ITERATION 20 STAGE 01 FORM 00 S IS CRACD NEW SOLUTION

J	BETA	I	B	PI
	14608.98597677		.	1.00000000
	. -	1	.	.
CRACD	16.66624016	2	9500.00000000	.
UP003	8500.00000000	3	8500.00000000	.
UP002	3166.66534211	4	8000.00000000	.
CRUD3	.	5	6333.33465788	1.57199711
CRACF	3483.33375983	6	.	2.49199798
CRUD1	6333.33465788	7	.	4.00000000
STOVE	2726.66603035	8	.	4.19999980
DIESL	1249.99948342	9	3500.00000000	1.33320054
COMPD	205.16659866	10	.	4.00000000
GAS	1319.99890009	11	.	4.09999990
UP004	7999.99999999	12	.	10.18000792
COMPA	205.66658141	13	.	4.29999995
CASIN	349.33317459	14	.	3.29999995

ULLMANS ILLUSTRATIVE LP MODEL OF OIL REFINERY SCHEDULING

ITERATION 21 STAGE 01 FORM 00 S IS COMPC NEW SOLUTION

J	BETA	I	B	PI
	11262.98778765		.	1.00000000
	.	1	.	.
CRACD	933.33273993	2	9500.00000000	.
UP003	8500.00000000	3	8500.00000000	.
UP002	4833.33184983	4	8000.00000000	.
COMPC	139.99983088	5	4666.66815016	1.86899859
CRACF	2566.66726006	6	.	3.02800065
CRUD1	4666.66815016	7	.	4.00000000
STOVE	2193.33285119	8	.	4.19999980
DIESL	.	9	3500.00000000	.79199783
COMPD	499.33310932	10	.	4.00000000
GAS	1119.99910990	11	.	5.75000785
UP004	7999.99999999	12	.	8.19999829
COMPA	247.33318053	13	.	4.29999995
CASIN	382.66644117	14	.	3.29999995

ULLMANS ILLUSTRATIVE LP MODEL OF OIL REFINERY SCHEDULING

ITERATION 22 STAGE 01 FORM 00 S IS UP009 NEW SOLUTION

J	BETA	I	B	PI
	.		.	1.00000000
	.	1	.	.
CRACD	.	2	9500.00000000	.
UP003	8500.00000000	3	8500.00000000	.
UP002	9499.99999999	4	8000.00000000	.
COMPC	.	5	.	2.00759910
CRACF	.	6	.	3.28400167
CRUD1	.	7	.	4.00000000
STOVE	.	8	.	4.19999980
UP009	3499.99999999	9	3500.00000000	.54119685
COMPD	.	10	.	4.00000000
GAS	.	11	.	4.09999990
UP004	7999.99999999	12	.	10.18000732
COMPA	.	13	.	4.29999995
CASIN	.	14	.	3.29999995

ULLMANS ILLUSTRATIVE LP MODEL OF OIL REFINERY SCHEDULING

ITERATION 24 STAGE 01 FORM 00 THETA AT MAXIMUM

J	BETA	I	B	ER	
	.		.	.	
	.	1	.	.	
CRACD	.	2	9500.00000000	.	-
UP003	8500.00000000	3	8500.00000000	.	-
UP002	9499.99999999	4	8000.00000000	.	-
COMPC	.	5	.	.	
CRACF	.	6	.	.	-
CRUD1	.	7	.	.	-
COMPB	.	8	.	.	-
UP009	3500.00000000	9	3500.00000000	.	
CRACS	.	10	.	.	-
GAS	.	11	.	.	-
UP00A	7999.99999999	12	.	.	-
COMPA	.	13	.	.	-
CASIN	.	14	.	.	

ULLMANS ILLUSTRATIVE LP MODEL OF OIL REFINERY SCHEDULING

ITERATION 24 STAGE 02 FORM 00 PRIMAL-DUAL SOLUTIONS

J	BETA	I	B	PI
	.		.	1.00000000
	.	1	.	.
CRACD	.	2	9500.00000000	.
UP003	8500.00000000	3	8500.00000000	.
UP002	9499.99999999	4	8000.00000000	. -
COMPC	.	5	.	3.83489916
CRACF	.	6	.	4.82800107
CRUD1	.	7	.	7.63125298
COMPB	.	8	.	5.52250343
UP009	3500.00000000	9	3500.00000000	. -
CRACS	.	10	.	11.47501677
GAS	.	11	.	4.09999990
UP004	7999.99999999	12	.	4.19999980
COMPA	.	13	.	4.29999995
CASIN	.	14	.	3.29999995

ULLMANS ILLUSTRATIVE LP MODEL OF OIL REFINERY SCHEDULING

ITERATION 2 STAGE 00 FORM 00 S IS DIESL CYCLE PRINT

J	BETA	I	E	PI
	.		2.20000004-	.
FUEL	.	1	1.00000000	.
UP002	9500.00000000	2	.	.
UP003	8500.00000000	3	.	.
UP004	8000.00000000	4	.	.
UP005	14000.00000000	5	.	.
DIESL	.	6	1.00000000-	.
	.	7	1.00000000	.
-STOVE	.	8	.	.
UP009	3500.00000000	9	.	.
-COMPD	.	10	.	.
-COMPC	.	11	.	.
-COMPB	.	12	.	.
-COMPA	.	13	.	.
-CASIN	.	14	.	.

ULLMANS ILLUSTRATIVE LP MODEL OF OIL REFINERY SCHEDULING

ITERATION 1 STAGE 00 FORM 00 CHECK SOLUTION

J	BETA	I	B	ER	
	.		.	.	-
FUEL	.	1	.	.	-
UP002	9500.00000000	2	9500.00000000	.	-
UP003	8500.00000000	3	8500.00000000	.	-
UP004	8000.00000000	4	8000.00000000	.	-
UP005	14000.00000000	5	14000.00000000	.	-
	.	6	.	.	-
	.	7	.	.	-
	.	8	.	.	-
UP009	3500.00000000	9	3500.00000000	.	-
	.	10	.	.	-
	.	11	.	.	-
	.	12	.	.	-
	.	13	.	.	-
100000	.	14	.	.	-

ULLMANS ILLUSTRATIVE LP MODEL OF OIL REFINERY SCHEDULING

ITERATION 8 STAGE 00 FORM 00 END OF STAGE

J	BETA	I	B	ER	
	.		.	.	-
FUEL	.	1	.	.	-
UP002	9500.00000000	2	9500.00000000	.	-
UP003	8500.00000000	3	8500.00000000	.	-
UP004	8000.00000000	4	8000.00000000	.	-
UP005	14000.00000000	5	14000.00000000	.	-
DIESL	.	6	.	.	-
STOVE	.	7	.	.	-
COMPD	.	8	.	.	-
UP009	3500.00000000	9	3500.00000000	.	-
COMPC	.	10	.	.	-
COMPB	.	11	.	.	-
COMPA	.	12	.	.	-
CASIN	.	13	.	.	-
	.	14	.	.	-

ULLMANS ILLUSTRATIVE LP MODEL OF OIL REFINERY SCHEDULING

ITERATION STAGE 00 FORM 00 END OF PHASE ONE

J	BETA	I	B	ER
	.		.	.-
	.	1	.	99999999.00000000-
UP002	9500.00000000	2	9500.00000000	9.19743010-
UP003	8500.00000000	3	8500.00000000	.-
UP004	8000.00000000	4	8000.00000000	5590307.67140996
UP005	14000.00000000	5	14000.00000000	6.09523777-
-FUEL	.	6	.	.
-DIESL	.	7	.	.
-STOVE	.	8	.	.
UP009	3500.00000000	9	3500.00000000	.
-COMPD	.	10	.	.
-COMPC	.	11	.	.
-COMPB	.	12	.	.
-COMPA	.	13	.	.
-CASIN	.	14	.	.

ULLMANS ILLUSTRATIVE LP MODEL OF OIL REFINERY SCHEDULING

ITERATION 8 STAGE 00 FORM 00 BASIS INVERTED

J	BETA	I	B	ER	
	.		.	.	-
FUEL	.	1	.	.	-
UP002	9500.00000000	2	9500.00000000	.	-
UP003	8500.00000000	3	8500.00000000	.	-
UP004	8000.00000000	4	8000.00000000	.	-
UP005	14000.00000000	5	14000.00000000	.	-
DIESL	.	6	.	.	-
STOVE	.	7	.	.	-
COMPD	.	8	.	.	-
UP009	3500.00000000	9	3500.00000000	.	-
COMPC	.	10	.	.	-
COMPB	.	11	.	.	-
COMPA	.	12	.	.	-
CASIN	.	13	.	.	-
	.	14	.	.	-

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